SOME PHYSIOLOGICAL FACTORS AFFECTING THE NODULATION OF LEGUMINOUS PLANTS

BY

DARREL LUVENE LYNCH

B.S., University of Illinois, 1947
M.S., University of Illinois, 1948

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN AGRONOMY
IN THE GRADUATE COLLEGE OF THE
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Introduction

Nodule formation by leguminous plants and nitrogen fixation by their nodule bacteria (*Rhizobium spp.*) have been studied intensively for many years. Numerous theories have been advanced to explain the fundamental bases of nodulation and nitrogen fixation, but thus far the "roles of the respective symbionts in the rhizobia:plant complex" have not been identified.

Well-designed laboratory and greenhouse studies have shown that susceptibility and resistance of leguminous plants to infection by the nodule bacteria are controlled by quantitative genetic factors. The physiological nature of this inheritance has not been resolved, however. Information which would contribute to an understanding of the physiological nature of nodulation was sought in this study.

Materials and Methods

A new tool was used to re-evaluate the nodulation process. This tool consisted of two soybean selections which varied only in their nodulating ability. One of these selections was abundantly nodulated by many strains of soybean nodule bacteria, while the other selection was nodulated by only a few strains of soybean bacteria. These plants and their respective nodule bacteria were subjected to numerous analyses and treatments.

Inheritance studies were made with the F1, F2, and F3 progeny from crosses of the two soybean selections. In order to investigate the nodulation processes, root hair development and grafting techniques were used. Plants from both selections were analyzed for amino acid and sugar content. The plant-growth promoters, indole-3-acetic acid, indolebutyric

acid, parachlorophenoxyacetic acid, and alpha-naphthaleneacetic acid, as well as the plant-growth inhibitors, gamma-phenylbutyric acid and 2,3,5-triiodobenzoic acid were tested for their effect upon nodulation.

The resistant soybean as a selecting agent was tested by serial passages of a number of strains of nodule bacteria through this plant. Fermentation reactions of these strains were noted after plant passages.

The soybean selection resistant to nodulation is designated by *r*; the normal selection is designated by *R*.

Results and Conclusions

1. The *r* plants were nodulated by only 6 of 35 strains of nodule bacteria; only 1 strain nodulated *r* plants grown in field soils.

2. Resistance to nodulation by the *r* plants was controlled by a single recessive gene; conversely, the factors for nodulation were controlled by dominant characteristics.

3. The resistance to nodulation shown by the *r* plants was not due to morphological peculiarities of the root hairs of these plants.

4. The sugar and amino acid content of the plant materials of both selections showed no qualitative differences when analyzed by means of paper-partition chromatography.

5. Para-chlorophenoxyacetic acid produced proliferations containing nodule bacteria on the roots of both selections. This acid also increased the number of nodules on the *r* plants nodulated by strains 311b2, 510, and 311b11.

6. Other growth-promoting substances were ineffective or erratic in their influence upon nodulation.

7. Plant-growth inhibitors reduced the number of nodules on plants of both soybean selections.

8. Ferric phosphate, indole-3-acetic acid, and vitamins

altered the number and size of nodules and the nitrogen content of *r* plants inoculated with certain strains of rhizobia and plant-passage isolates.

9. The plant-passage isolates differed from the stock culture rhizobia by:

a. Reaction on litmus milk, sugars, and carbohydrates.

b. Amount of gum production and rate of growth.

c. Degree of nodulation and nitrogen fixation with the *r* plants.

d. Conversion of tryptophane to indole-3-acetic acid.

10. The stock culture rhizobia which nodulated the *r* plants could be differentiated from those which did not by the amount of gum produced and the rate of conversion of tryptophane to indole-3-acetic acid.

11. An unknown substance toxic to soybean nodule bacteria was present in juices of the *r* plants.

12. The nitrogen secured from the air by selection *R* was inversely proportional to the supply of available nitrogen in the soil.

VITA

The author was born February 6, 1921, at Dewey, Oklahoma. He graduated from high school at Popular Bluff, Missouri, in 1940. He attended the University of Missouri from September 1940 until June 1943. He then served for two and one-half years in the Army. In June of 1946 he entered the University of Illinois and in August 1947 was graduated with high honors, receiving the Bachelor of Science degree in Agriculture. He then enrolled in the Graduate College of the University and in October 1948 received the degree of Master of Science in Agronomy.

The author has been employed for four years by the Agronomy Department of the University of Illinois as an Instructor and an Assistant in Soil Biology.

He is a member of Gamma Sigma Delta, Phi Kappa Phi, and Sigma Xi.

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